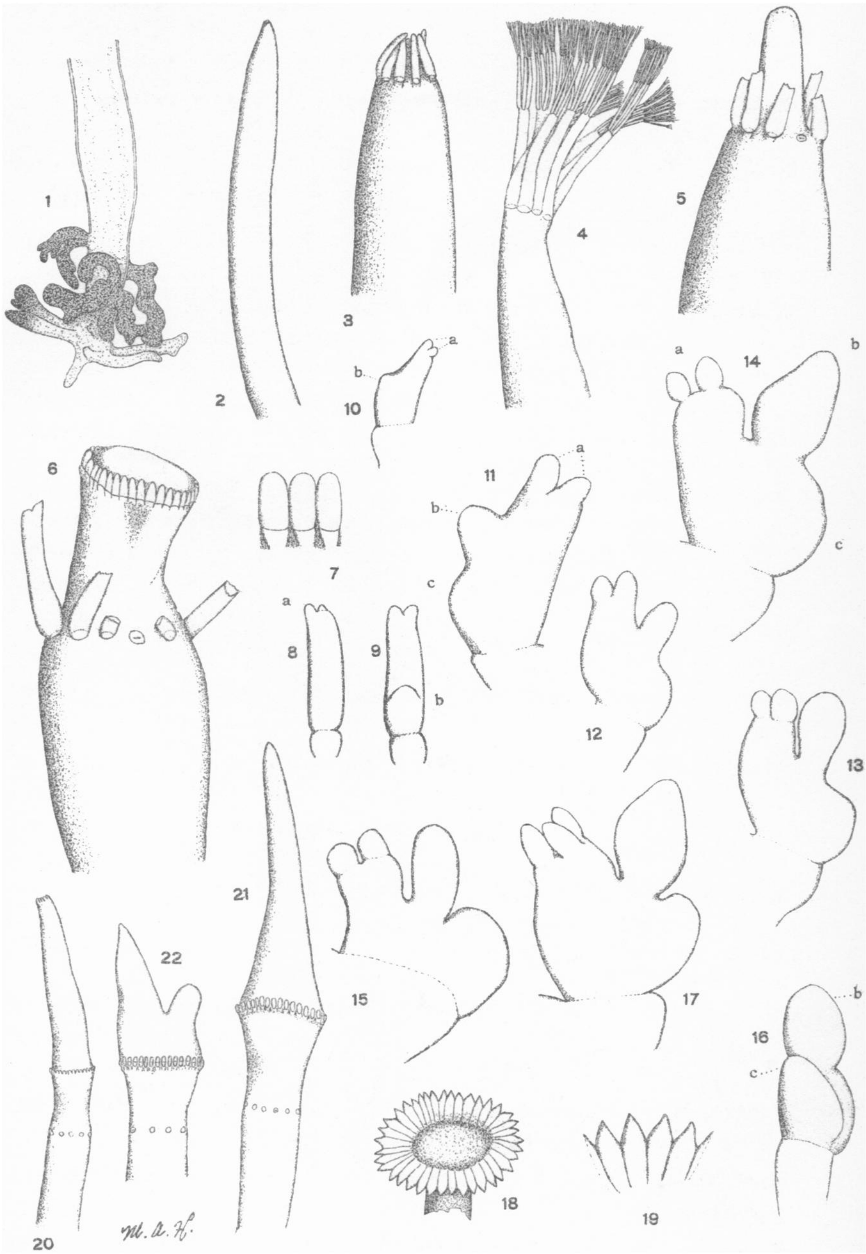
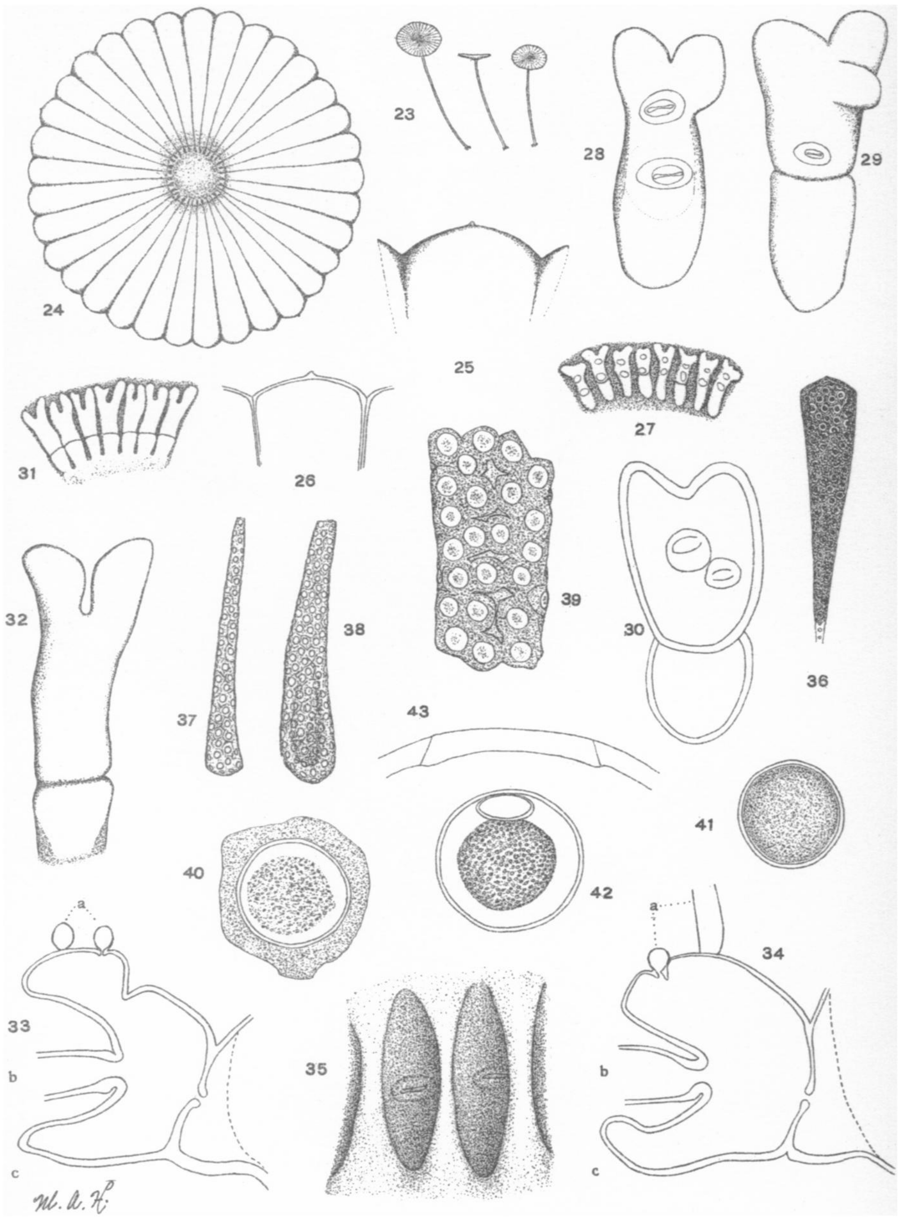


1-16, 18-22. ACICULARIA SCHENCKII (Möb.) Solms
17. ACETABULUM CRENULATUM (Lamx.) Kuntze



ACICULARIA SCHENCKII (Möb.) Solms

VOL. 28 NO. 6

BULLETIN

OF THE

TORREY BOTANICAL CLUB

JUNE 1901

Observations on the Algal Genera Acicularia and Acetabulum

BY MARSHALL A. HOWE

(WITH PLATES 24 AND 25)

I. ACICULARIA SCHENCKII (Möb.) Solms

1. **Historical.**—The material from which *Acicularia Schenckii* was originally described came from Cabo Frio, Province of Rio de Janeiro, Brazil, where it was collected by Professor H. Schenck in May, 1887. It was first made known under the name *Acetabularia Schenckii* by Dr. M. Möbius in Hedwigia for 1889 (**28**: 318–320. *pl. 10. f. 8–12*). But in this species the aplanospores surround themselves each with a thick calcareous shell and these shells adhere, so that the aplanospores, by the decay of the sporangium wall, are left in a single coherent mass, retaining more or less the form of the sporangium; and on this ground, Graf zu Solms-Laubach in his Monograph of the Acetabularieae, published in 1895,* refers the species to the genus *Acicularia*, previously recognized only in the fossil state. The genus *Acicularia* was founded in 1843 by the French paleontologist d'Archiac,† the original species being *Acicularia Pavantina* from the Middle Eocene at "Pisseloup près Pavant." It was referred to the animal kingdom by d'Archiac, and this opinion as to its nature was generally held until

* Trans. Linn. Soc. Bot. II. **5**: 1–39. *pl. 1–4.*

† d' Archiac. Description géologique du Départment de l'Aisne. Mém. de la Soc. géol. de France, 5^2: 386. *pl. 25. f. 8.* 1843.

[Issued June 19th]

1877, when Munier-Chalmas * placed it among the Algae next to *Acetabulum*. This idea Count Solms considers to be confirmed in a brilliant fashion by the discovery of a living species the spores of which are surrounded with lime and are coherent in masses strongly resembling the fossil "spiculae" on which alone the genus *Acicularia* was established. The description and figures given by d'Archiac of his "*polypier aciculaire*" deal only with its external characters, and if the more detailed account of *Acicularia Pavantina* given by Reuss † in 1861 can be depended upon, the affinities of this organism would seem to be still open to question, for the cavities supposed by Munier-Chalmas and Solms-Laubach to have been occupied by the aplanospores would appear from Reuss's figures to be somewhat narrowly and irregularly conical with the point directed inward. And in writing of the mouths or openings which are seen on the surface of the spicula, Reuss states, "Sie führen in nicht sehr tiefe Zellen, die in ihrer ganzen Weite ausmünden. Jede derselben ist, wie bei den Eschariden und Celleporiden, mit jeder der nebenliegenden durch einen feinen kurzen Canal verbunden." Count Solms ‡ remarks that he saw only one complete spicula of *Acicularia Pavantina* and is not able to express an opinion as to the internal form of the cavities. We have made several efforts to locate the type material of *Acicularia Pavantina*, with the hope of being able to see it and of being thus in a better position to hold an opinion as to whether the original *Acicularia Pavantina* and the *Acicularia Schenckii* are really congeneric, but our attempts thus far have been unsuccessful. § That the more recently described fossils, *Acicularia miocaenica* Reuss and *Acicularia Andrussowii* Solms, are closely allied to the living *A. Schenckii* would seem from published descriptions and figures to be very clear. The calcareous coating of the spore-walls and

---

* Observations sur les Algues calcaires appartenant au groupe des Siphonées verticillées (Dasycladées Harv.) et confondues avec les Foraminifères. Comptes-rendus de l'Acad. **85** : 814–817. 28 O. 1877.

† Reuss, A. E. Ueber die fossile Gattung *Acicularia* d'Arch. Sitzungsberichte der k. Akad. Wiss. **43**[1] : 7–10. *pl.* 1861.

‡ Trans. Linn. Soc. Bot. II. **5** : 35. 1895.

§ An intimation as to the whereabouts of the d'Archiac collection comes to hand when the publication of this paper is so far advanced as to render further delay inadvisable.

the cohesion in a single mass are the only characters separating *Acicularia*, as defined by Solms-Laubach, from the genus *Acetabulum*, and while a segregation on this ground is doubtless defensible, the propriety of thus using the generic name *Acicularia* perhaps awaits the further study of the fossil remains on which the genus *Acicularia* was founded.

The specimens on which the following observations were made were collected by the writer at Hungry Bay, Bermuda, on June 25, 1900. The plants were growing on small stones at about the low tide mark in a shallow creek leading out from a mangrove thicket. Through the kindness of Professors Möbius and Schenck we have been permitted to see the original Brazilian material of *Acicularia Schenckii*. A careful comparison of this and the Bermudian specimens reveals a few slight differences which are not, we believe, of specific significance. The differences are referred to below. Count Solms states that Goebel collected beautiful specimens of this species in Curaçoa and that it has been collected also in Martinique and Guadaloupe. But its occurrence now in Bermuda, about a thousand miles farther north, is in itself a point of some little interest.

2. Descriptive.

ACICULARIA SCHENCKII (Möb.) Solms, Trans. Linn. Soc. Bot. II. **5**: 33. *pl. 3. f. 9, 11, 12, 14, 15.* 1895.

Acetabularia Schenckii Möb. Hedwigia, **28**: 318–320. *pl. 10. f. 8–12.* 1889.

Green at first, becoming strongly calcified and chalky white with age: disc very nearly flat, solitary, 4–6 mm. in diameter, the margin crenulate; sporangia 30–42, cuneate, strict, firmly connate at maturity except as to the rounded-obtuse minutely mucronate apex, the free extremities conical when young; coronal processes mutually free, emarginate or emarginate-bilobed, with or without a transverse invagination, each bearing two caducous polytomous branches or the rudiments or scars thereof; hypopeltal processes emarginate-bilobed, sometimes twice dichotomous: aplanospores 100–200 in a sporangium, globose, 66–84 μ in diameter; the calcareous massula subcuneate, rounded or somewhat truncate at the distal extremity, exposing the imbedded aplanospores over its entire surface, usually thicker in the vertical plane than in the horizontal (tangential), the radial sides often concave toward the

enlarged outer end: rhizoids often irregularly inflated and filled with densely granular reserve-food materials: stipe 1–2.5 cm. (mostly 1.5 cm.) long, .28–.48 mm. in thickness: primary sterile branches 8–18 in a whorl (commonly solitary), finally 4 times (rarely 5 times) polytomous, the ramuli usually in 4's, the ultimate often in 3's or 2's.

The membranes throughout are thinner in the Bermudian plants than in the Brazilian, though susceptible to some variation in both. The wall in the apical region of the mature sporangium is in the former mostly about 9 μ in thickness while in the latter it ranges from 12 μ to 24 μ (measured after decalcification in both). But in only one sporangium, out of many examined, of the specimens collected by Dr. Schenck, have we seen the membrane relatively so thick as is indicated in Möbius' figure 12 (Hedwigia, **28**: *pl. 10.* 1889). Again, the coronal processes in the Bermudian plant are less emarginate or lobed and the hypopeltal processes less often show a tendency to become twice dichotomous, but these characters are extremely variable in both.

Professor Schenck writes that his specimens also were collected in a mangrove formation.

Apart from the other important differences, *Acicularia Schenckii* is very distinct from *Acetabulum crenulatum* (Lamx.) Kuntze in general habit and appearance, differing at first sight in being much smaller in all its parts and in the nearly flat discs.

By using some care, the contents of a mature sporangium can be removed in a single coherent conico-prismatic or subcuneate mass (Figs. 37 and 38), as happens in nature by the decay of the sporangium wall. By reflected light, under low magnification, one of these bodies appears white, with the light green aplanospores occupying slight depressions or pits on the surface, but higher magnification shows that the pitted appearance is largely an optical illusion; for unless the aplanospores have collapsed in the process of preservation — which sometimes happens even in formalin material—their outer surface is on about the same level with the surrounding matrix. It is a point of some biological interest that the side of the aplanospore which lies toward the surface of the massula is always the one which bears the lid, and in the lid region, so far as we have observed, is always free from the

calcareous incrustation ; and every spore seems to have a surface exposure. When the massula, viewed from above, appears unusually broad, it can be shown to be hollow toward the larger end. In most cases, however, it is solid, except for the small interstices, and toward the larger extremity is concave at the sides (Figs. 37 and 38), so that a vertical transverse section has somewhat the form of a biconcave lens. This arrangement, whereby each aplanospore has its lid-bearing surface exposed and uncalcified, is an interesting adaptive feature which seems to have escaped formal recognition hitherto. Count Solms-Laubach in figuring * a portion of the surface of a massula does not fail to indicate that the lids of some of the spores are visible, but in describing the "lime-spicula" (our *massula*) he writes † as follows : "It consists of a strongly calcified substance enclosing numerous cavities lying near the surface, and consequently transparent. In each of these and completely filling it there is a spore of the same structure as those of *Acetabularia*. It follows that the pits of the fossil forms are the spore-containing cavities from which the spores have disappeared and the external lime-covering has not been preserved, so that they appear as opening outwards."

In the Bermudian specimens, and in the Brazilian so far as we have seen them, the spore-cavities not only lie "near" the surface but actually reach the surface and for a region approximately corresponding to the spore-lid there is no "external lime-covering" to disappear ; and the cavities not only "appear as opening outwards," but such is actually the case from the beginning. This is shown in an especially striking fashion when massulae from formalin-preserved material are allowed to dry on a glass slide and are observed under comparatively low magnification with reflected light. The spores in shrinking away from the surface leave actual openings. It can be determined more accurately by use of high powers and transmitted light that the lid is either wholly free from the calcareous coating or is at most but partially covered with an unimportant amount of it.

By transmitted light, the matrix is yellowish, minutely granular, and somewhat waxy in appearance. As has already been

* *l. c., pl. 3. f. 9.*

† *l. c.* 10.

remarked by Solms-Laubach, the calcareous matter seems to envelop each spore separately like a shell, with a definite though commonly irregular boundary, and the massula (spicula) is apparently formed by the cohesion of these shells. Empty interstices, triangular or varied in form, are often to be seen among adjacent shells. Solms-Laubach inclines to the view that a sort of slime is formed from the outer surface of the spore-wall and that the lime is deposited in this, a cuticle being afterwards reformed inside the shell of lime. An alternative supposition, namely, that the lime is first deposited in a residual substance left in the sporangium after the formation of the spores, seemed to him less probable on account of the peculiar distribution of the lime. With the hope of throwing a little more light on this point, we have made an effort to see the spores in the earlier stages of development, using both dry material and that preserved in formalin. We are confident that in the great majority of cases, at least, the lime first appears as a very delicate coating on the outer surface of the spore-wall and that this coating gradually increases in thickness. The presence of a coating of slime or mucilage could not be demonstrated with certainty at any stage, though the ordinary mucilage tests were employed. Nevertheless, certain optical appearances give ground for the suspicion that something of the kind is present. The few cases in which the lime seemed to make its first appearance in a possible residual matter of the sporangium could be attributed to a disturbance of the natural relations in manipulating the specimen. The sporangium walls are more or less calcified and opaque when the formation of the spores begins and it therefore becomes necessary to remove or decalcify the walls before a clear view of the contents can be obtained, but decalcification is naturally out of the question when the mode of origin of the calcareous shells of the spores is the point under investigation.

3. **Developmental.**—It was noted by Strasburger* in 1877 that *Acetabulum Androsace* (Pallas) Kuntze [*Acetabularia Mediterranea* Lamx.] has a perennial basal portion consisting of rhizoids densely filled with reserve food materials. Similar rhizoidal reservoirs which apparently persist are now found in *Acicularia Schenckii* (Fig. 1).

---

* Bot. Zeit. **35**: 715–718. 1877.

As has already been described for *Acetabulum Androsace* and *A. crenulatum*, the young shoot in *Acicularia Schenckii* is an erect cylindrical or often somewhat curved tube, with a tapering subacute or rounded apex. In two cases out of the many young plants examined, we have observed the beginnings of a dichotomous branching (Fig. 22); in all other cases the shoots have been simple. The development of the primary whorls of articulated sterile branches offers no peculiarities worthy of special mention except the fact that we have been unable to find more than one whorl of such branches persisting at any one time. Harvey* figures in the young plant of *Acetabulum crenulatum* previous to the formation of the fertile disc three whorls of sterile branches and the beginning of a fourth and Woronin † gives a similar figure for *Acetabulum Androsace*. In *Acicularia Schenckii* two or three whorls are sometimes developed in succession before the formation of the disc, but in such the lower whorl has fallen by the time the next higher appears, and only scars remain to testify to its former existence. We have found no conclusive evidence that a plant of *A. Schenckii* ever matures more than one fertile disc. One case has been met with, in which a single shoot bore the beginnings of two discs separated by the scars of a whorl of sterile filaments, but in this the lower of the two rudiments showed unmistakable indications of arrested development in small size, unequal growth, and occasionally exfoliated members, and the suspicion that it was destined to no further growth seems well grounded. A case in which the development of a disc seems similarly arrested and the continuation of the axis shows the beginnings of a sterile whorl is represented in Fig. 20. Fig. 21 shows the scars of a delapsed disc and the prolification of the axis, but there is no proof that the delapsed disc reached maturely or that, if it did, another disc would actually reach the spore-bearing stage. Yet it must be admitted that cases like those just described suggest the possibility that a plant may occasionally mature two discs.

With the aid of material preserved in formalin, we have been able to follow out stages in the development of the disc which have been observed hitherto only in *Acetabulum Androsace* and

* Ner. Bor.-Am. **3** : *pl. 42*. 1858.

† Ann. Sci. Nat. Bot. IV. **16** : *pl. 8*. 1862.

more completely in some respects than is indicated in the recorded observations on that species. This practically complete series of early stages in the development of the disc seems to confirm, with much certainty, the morphological explanation of the disc put forward by Count Solms-Laubach in 1895, and perhaps justifies carrying his idea a little further. The disc begins as a whorl of ovoid protuberances, which are at first free from each other, though in close juxtaposition. A little later, these processes become oblong-cylindrical or somewhat tongue-shaped in outline (Figs. 6–8). The formation of the partial partition constituting the distal boundary of the vestibule at the base of each process begins very early (Figs. 6 and 7). In fact it seems to be formed almost simultaneously with the process itself, for we have been able to find no stage so young as to show no trace of it. The next step is the appearance of the rudiments of the two articulated sterile branches (Fig. 8), which begin as dome-shaped protuberances at the apex of the process. It is of interest that these protuberances commonly do not at first stand one in front of the other or in line with the radius of the disc, as they usually seem to do at a later time, but are almost side by side in line with a tangent to the disc. And when, as rarely happens, three rudiments of sterile branches appear instead of two, the three are never in a straight line but form an evident terminal verticil. The later development commonly thrusts them nearly into a radial line, but there are some exceptions to this as will be seen from our Fig. 30. In the course of time, each of these outgrowths becomes strongly constricted in the zone of emergence from the body of the original process and is at length in communication with it only by a narrow slit which is bounded by a callus-like thickening of the membrane. And this narrow slit is evidently closed in the scars which remain after the fall of the sterile filaments. Closely following the appearance of the rudiments of the sterile branches, the first indication of the origin of the sporangium may be recognized. The sporangium begins as a rather broad out-pocketing on the outer face of the original process at about its middle or sometimes nearly as low as the basal third (exclusive of vestibule). It is from the first broader than the rudiments of the sterile branches and though it becomes somewhat constricted at its base

this constriction is not so pronounced as in the case of the sterile branches. The young sporangia are at first abundantly free from each other. They are at an early stage short-cylindrical or somewhat club-shaped, with a rounded-obtuse apex (Figs. 12, 13, 15), but a little later, when they come to be coherent laterally, each has a free apex that is decidedly conical or conico-mammillate (Fig. 19). While, however, the disc is still very small, the end of the sporangium broadens out and nothing but a small mucro remains to represent the conical apex of the earlier stage, and even this mucro is sometimes obscure or obsolete. The hypopeltal process (segment of the *corona inferior* of Solms-Laubach) originates a little later than the sporangium. It begins as a broad dome-shaped outgrowth involving the whole region between the base of the sporangium and the vestibule-wall. Its further development offers nothing worthy of special comment unless it be the fact that it becomes strongly emarginate or emarginate-bilobed. That the hypopeltal process bears neither polytomous filaments nor the rudiments of them is well understood. It has already been noted that the rudiments of the polytomous filaments at the time of their emergence from the previously undifferentiated primordial ray are terminal in position. Later, however, the region just below them on the side toward the sporangium grows out into what is finally the emarginate or emarginate-bilobed apex of the coronal process. In reality, the organic apex of the ray as a whole is doubtless still to be found somewhere between the points of insertion of the two polytomous branches or their rudiments, having been thrust into an apparently lateral position by the development of the three superposed lateral outgrowths, namely, the sporangium, the hypopeltal process, and the terminal portion of the coronal process. The developmental history of the ray thus forces us to accept in the main the views of Solms-Laubach in regard to the morphological homologies of the disc and its parts, as opposed to the views of Falkenberg,* Cramer,† and Wille.‡ *The whole disc or cap* (including sporangia, coronal and

* Falkenberg, P. Schenck, Handbuch der Botanik, **2**: 270. 1882.

† Cramer, C. Denkschr. Schweiz. natf. Gesellsch. Zurich, **30**:—(35). 1887.

‡ Wille, N. Engler & Prantl, Die natürlichen Pflanzenfamilien, 1^2: 152–159. 1890.

hypopeltal processes, polytomous disc-filaments, etc.) *evidently is not a complicated aggregation of whorls of primary branches and the sporangia are, with little doubt, not to be compared with the ordinary verticillate branches or branchlets.* As Solms-Laubach has maintained, the sporangia in the Acetabuleae are most naturally to be compared with those of *Bornetella*, in which genus the sporangia arise laterally and irregularly from the primary whorled branches (*i. e.*, from the branches of the "first generation") and have no evident homologies with the verticillate sterile branches. It may be remarked that, according to Cramer, the sporangia in *Bornetella nitida* (Harv.) Mun.-Chal. occur singly on the branches of the first order, while in *B. capitata* (Harv.) J. G. Ag., they are more numerous, ranging from 9 to 35 for a single branch. Now in view of the fact that in the Acetabuleae (if our observations on *Acicularia Schenckii* and *Acetabulum crenulatum* * may be considered typical for the group) the hypopeltal process and the distal portion of the coronal process are lateral outgrowths like the sporangium, we are of the opinion that these structures are best looked upon as abortive sporangia. The logical result of this comparison of the ontogeny of the ray with the relation of parts in *Bornetella* is the conclusion that *the whole cap, with all its radially arranged parts except the vestibules, corresponds to a single primary whorl of branches.* The original outgrowth which gives rise to the terminal rudiments and to the lateral sporangia is the branch of the first order (*i. e.*, corresponds to the first segment of the ordinary primary branch), whence it follows that the sterile polytomous filaments which may arise from it later are branches of the second order. The *velum partiale*, as it might be called, which separates the base of the ray (the chamber of Cramer's "Zwischenstück") from the vestibule (Figs. 33 and 34) is evidently homologous with the constriction which separates the base of the primary sterile branch from the main axis of the plant. It is here that the ray detaches itself when the cap finally falls—though the fertile sporangia alone are often first detached. In this connection, it is of interest to note that the primary sterile branches show at their beginning distinctly recognizable basal cushions corresponding to

* See page 331.

vestibules, though these afterward become obscure. It may be remarked, too, whether significant or not, that the vestibule communicates with the base of the ray by an elongated slit (Fig. 35) lying transverse to the main axis of the plant and that the passageway at the base of the primary sterile branch just previous to its final closure is a similar slit also transverse to the main axis of the plant (see scars in Figs. 5 and 6).

II. ACETABULUM CRENULATUM (Lamx.) Kuntze

Acetabulum crenulatum, like *Acetabulum Androsace*, as described by Strasburger,* and *Acicularia Schenckii*, as described above, has more or less enlarged rhizoids densely filled with a finely granular material which presumably serves as a reserve food supply. The mode of development of the disc and its parts is essentially as is described above for *Acicularia Schenckii*. As in that plant, one very rarely finds incipient rays which bear rudiments of three polytomous filaments instead of two and these are always equidistant in a terminal whorl. One such case is represented in our Fig. 17. It would be of interest if those who have access to the growing *Acetabulum Androsace* with its more numerous coronal "hairs" or hair-rudiments would determine whether or not these 4–7 outgrowths orginate in a perfect verticil. We are familiar only with the figures of Solms-Laubach bearing upon this point. His figure 4 (*l. c., pl. 1*) indicates the possibility of such an arrangement, but his Fig. 7, in which the sporangium is still in a very young stage shows the rudiments of the sterile branches in a straight radial row. From analogy with *Acicularia Schenckii* and *Acetabulum crenulatum* and from the relations of these parts as described by Solms for the matured *Acetabulum polyphysoides* and *Acetabulum Möbii*,† it is to be expected that the coronal "hairs" of each ray in *Acetabulum Androsace* also will be found to exhibit a terminal verticillate arrangement at the time of their origin.

III. ACETABULUM CARAIBICUM (Kütz.) Kuntze

Acetabulum Caraibicum, ‡ in our opinion, cannot be satisfactorily distinguished from *A. crenulatum*. Through the courtesy of

---

* Bot. Zeit. **35** : 715–718. 1877.

† *Acetabularia Möbii* Solms, Trans. Linn. Soc. Bot. II. 5^1 : 30. *pl. 4. f. 1.* 1895.

‡ *Acetabularia Caraibica* Kützing, Tab. Phyc. **6** : 33. *pl. 93.* 1856.

Mme. Weber-van Bosse, we have been able to see four of the six individual plants, by which, she writes, the evident type of the species is represented in the Kützing herbarium.

Graf zu Solms-Laubach, though admitting the close relationship of *Acetabulum crenulatum* and *A. Caraibicum*, attempts the following distinctions in his key * to the species of the genus :

"Disci infundibuliformes saepius plures superpositi, radiis apiculo convexo." *A. crenulatum*

"Discus planus, radiis apice emarginatis, apiculum parvum gerentibus." *A. Caraibicum.*

The alleged difference in the form of the disc appears not to be borne out either by Kützing's original figures or by the specimens preserved in his herbarium. In all the latter, so far as we have seen them, with one exception, the disc is as strikingly infundibuliform as in any condition of *A. crenulatum* ; and this one exception, if it may be so called, is a disc which has been artificially flattened on a piece of mica and evidently decalcified. Moreover, the discs are sometimes superposed in pairs in *A. Caraibicum*, as shown in the original figures and in the specimens themselves. The plants with two discs were made by Kützing to constitute his variety *calyculata*, but they were apparently growing with the others and do not deserve a varietal name any more than the similar conditions which have long been recognized in *A. crenulatum.* In regard to the apiculum, there is little difference. In Kützing's plants it is very conspicuous when the sporangium is young, but becomes more or less obscure with age—as also is generally acknowledged to be sometimes the case in *A. crenulatum.* The apiculum is, however, discernible in each of the four Kützingian plants examined. The paucity of the original material forbade any extended observations on the form of the apex of the mature sporangium in the soaked-out condition, but we found none so strongly emarginate as figured by Kützing. The apices of the matured sporangia appear rather to be merely truncate or slightly retuse, more as figured by Count Solms (*l. c., pl. 1. f. 10*), and we think it must be admitted that a subtruncate sporangium-apex is quite normal in *A. crenulatum.* Solms-Laubach mentions also the "slightly calcified cap" as one of the characters by which *Acetabulum Caraibicum*

* *l. c.* 20.

may be generally distinguished, but it seems to us that this description cannot well be applied to the plants of Kützing.

By way of further description of Kützing's specimens, it may be remarked that the number of sporangia in a disc varies from 32 to 52, that the largest disc seen is 7 mm. in diameter, and that the emarginate coronal processes bear two "hair-scars" or two undeveloped rudiments. The pocket in the Kützing herbarium bears the inscription, "*Acetabularia caraibica* Lamx.," though why the name should be attributed to Lamouroux is not quite clear. Another specific name, with "Kg." after it, was first written, but was so effectually scribbled out that we were unable to decipher it. The pocket is numbered 103 and at the bottom is written "Von den Antillen. Koch."

Explanation of Plates

PLATE 24

1–16 and 18–22. *Acicularia Schenckii* (Möb.) Solms.

17. From *Acetabulum crenulatum* (Lamx.) Kuntze.

1. Basal portion, showing rhizoidal food-reservoirs, × 28.

2. Apical portion of a young plant, × 16.

3. A later stage, showing beginnings of a primary whorl of sterile branches, × 55.

4. Apex of plant crowned with well-developed primary whorl of sterile polytomous branches, × 55.

5. Apex of plant at a little later stage; primary branches falling and main axis continuing its upward growth, × 55.

6. Apical portion of plant, showing beginning of a disc, × 55.

7. Three of the tooth-like processes constituting the young disc in Fig. 6, × 245, outer (distal) aspect.

8. Process from a slightly older cap-rudiment, distal aspect, × 245. At the apex (*a*) are seen the beginnings of what afterward will become the disc-filaments or the abortive rudiments of such.

9. The same a little more advanced, showing at *b* the first indication of the sporangium, × 245.

10. A similar process viewed laterally, × 245. The beginning of the sporangium at *b*.

11. A primary process from a more advanced stage of the disc, in lateral view, showing now at *c* the beginning of the hypopeltal process, × 245.

12–15. Similar and later stages from various young discs, lateral views, × 245.

16. A primary disc-forming process at a little later stage than the preceding, in distal view, × 245; *b*, the sporangium; *c*, the hypopeltal process. The true apex, with its two rudiments of disc-filaments, is hidden behind *b*.

17. A primary disc-forming process from *Acetabulum crenulatum*, showing rudiments of three disc-filaments in a terminal whorl, × 193.

18. Young disc of *Acicularia S henckii*, seen from above (slightly flattened under cover-slip), × 18. At this stage, with the present magnification, scarcely anything more than the conspicuously pointed young sporangia is visible.

19. Terminal portions of young sporangia from the preceding, × 40.

20. Prolification of axis, × 16. At about the lower third are scars left by the fall of a whorl of primary sterile branches; above this an apparently abortive disc-rudiment; at the apex, the beginnings of another whorl of primary sterile branches.

21. Prolification after the fall of a disc, × 16.

22. Prolification and dichotomy, × 16.

PLATE 25. *Acicularia Schenckii* (Möb.) Solms.

23. Plants with mature discs, natural size.

24. A mature disc viewed from above, × 7.

25. Apex of mature sporangium, surface view, showing the small terminal apiculum, × 40.

26. Another sporangium-apex in optical section after decalcification, × 40.

27. Coronal processes, × 55.

28. Coronal process, with two scars left by the fall of disc-filaments, × 245.

29. Coronal process with transverse invagination, one disc-filament-scar, and one abortive rudiment of a disc-filament, × 245.

30. Coronal process with transverse invagination, after decalcifying, × 245.

31. Hypopeltal processes, × 55.

32. A single hypopeltal process, with vestibule below, × 245.

33 and 34. Slightly diagrammatic radial sections, showing relations of the various parts of the disc, × 180. *a*, the disc-filaments or their rudiments; *b*, the sporangium; *c*, the hypopeltal process; the dotted line marks the inner lateral boundary of the vestibule. In Fig. 33 the coronal process shows a transverse invagination.

35. Vestibules viewed from the main axial cavity of the plant, × 245. In each, the passage-way leading into the coronal chamber is seen to be elongated transversely to the plant axis; the appearance of this passage-way in vertical section is shown in Figs. 33 and 34.

36. A single mature sporangium viewed from above, showing toward the apex the falling away of the sporangium wall and the resultant exposure of the aplanospores, × 16. Drawn from a glycerine mount. The aplanospores are as a rule less clearly visible through the sporangium wall, even in a glycerine mount, than the present figure would indicate.

37. A spore-mass (massula) removed from the sporangium entire, viewed from above or below (using these terms with reference to its former position in the disc), × 16.

38. The same massula in lateral view, × 16.

39. Portion of massula in surface view, × 55.

40. A single aplanospore with its calcareous incrustation, in optical section, × 193.

41. Aplanospore with calcareous coating fallen away, × 193.

42. Aplanospore, showing operculum, after treatment with strong acetic acid, × 245.

43. The operculum and adjacent portions of the aplanospore wall, in optical section, after treatment with strong acetic acid, × 750 (reduced from 1500).

COLUMBIA UNIVERSITY, May 16, 1901.